APPENDIX D

Estimated Los Angeles Background Ambient ETS Fine PM Concentration

Introduction

In this report, staff presents an exposure assessment based in part on quantitative estimates of time-weighted exposure for realistic scenarios which illustrate that Californians experience a range of ETS exposures depending upon lifestyle and daily routine. However, Californians who neither smoke nor associate with many smokers will have limited ETS exposure. In this case, individuals will likely experience the majority of their lifetime ETS exposure from the background ETS level which results from the contribution of steady state ETS emissions that routinely occur. The ETS background level in a small rural town may be undetectable due to its smoker population. But, the ETS concentration found in an urban area will be higher due to greater smoker population density and number of tobacco products smoked. Since most of California's population lives and works in urban areas, it would be helpful to ascertain what outdoor ambient ETS levels could be occurring in these areas. There is very limited published information on ambient ETS levels. Therefore, to calculate an urban ETS concentration, ARB staff estimated an outdoor ambient annual average ETS fine particulate matter (PM) concentration (i.e., $PM_{2.5}$ or less) for the Los Angeles area for 2003.

Background

The Los Angeles area estimate is derived from data collected from studies by Schauer *et al*., 1996 and Rogge *et al*., 1994. Both these studies estimated ETS fine particulate concentrations in the Los Angeles area using 1982 data. The Schauer *et al*., 1996 study determined a source apportionment of fine particulate mass concentrations and estimated a 1982 fine particulate annual average concentration of cigarette smoke through a chemical mass balance receptor model based on organic compounds. This model applied atmospheric organic compound concentration data and source emission profile data collected specifically for testing this model (Gray *et al*., 1986; Hildemann *et al*., 1991). The fine PM samples were collected from four sampling sites throughout the Los Angeles area: West Los Angeles, Downtown Los Angeles, Pasadena, and Rubidoux. Schauer *et al*., 1996, estimated the average 1982 fine PM annual average for ETS from these four sampling sites in the Los Angeles area to be 0.21 $\mu g/m^3$ by using the fine PM concentration data and source emission profile data.

The Rogge *et al*., 1994 study found that iso- and anteisoalkanes (C_{29}-C_{34}) are enriched in ETS particles and displays a concentration pattern characteristic of tobacco leaf surface waxes. These iso- and anteisoalkane (C_{29}-C_{34}) concentrations are distinctly different from leaf surface abrasion products shed from plant leaves that grow in the Los Angeles area and contain 40 times more in tobacco and ETS particles than leaf surface waxes from Los Angeles area plants. Four different cigarette categories – nonfilter, filter, light, and menthol were used. For each cigarette category, one of the five most popular cigarette brands was tested to determine an average emission rate for ETS fine

PM. Exhaled mainstream and sidestream smoke generated by human smokers were collected. Isoalkane and anteisoalkane emission rates were then determined from fine particulate ETS per cigarette (Table 1, Rogge *et al*., 1994). Rogge *et al*. then utilized 1982 ambient isoalkane and anteisoalkane monitoring for the Los Angeles area (West Los Angeles, downtown Los Angeles, and Pasadena monitors) to estimate an isoalkane/anteisoalkane concentration. By using a fine particulate mass emission rate per cigarette from Hildemann *et al*., 1991, Rogge *et al*. estimated ambient ETS marker concentrations by the emission rate ratio of fine PM to isoalkanes, multiplied by the 1982 ambient isoalkane and anteisoalkane concentrations. The average 1982 Los Angeles outdoor ambient fine particulate cigarette smoke concentration was found by Rogge, *et al.* to be approximately 0.28-0.36 $\mu g/m^3$.

Staff Estimate

The Rogge *et al*., 1994, and Schauer *et al*., 1996, studies estimated annual average ETS fine particulate concentrations in the Los Angeles area for the year 1982. To estimate a 2003 Los Angeles annual average ETS fine particulate concentration, staff applied an adjustment to the 1982 PM estimates to reflect reductions in cigarette consumption and cigarette PM emission rates between 1982 and 2003 (Table D-1).

Table D-1

Estimated Ambient ETS Fine PM Concentration for the Los Angeles Area

		1982	2003	% Difference
Statewide Emissions	Total California Cigarettes	*57.3 billion	*23.5 billion	59
	ETS PM Emission Rate	20.4 mg/cig (1981 data)	13.4 mg/cig (1994-1998 data)	33
	Statewide ETS Fine PM Emissions (tons/year)	1,290	348	73
Estimated Los Angeles Conc.	Modeled ETS PM conc. ($\mu g/m^3$) Schauer *et al.* 1996	0.21	** 0.06	
	Measured ETS PM conc. ($\mu g/m^3$) Rogge *et al.* 1994	0.28 – 0.36	** 0.08 – 0.10	

* Board of Equalization data

** Estimated 2003 ambient ETS fine particulate concentration

Methodology

We compared the estimated statewide ETS PM emissions for 1982 and 2003 to determine what change had occurred in mass emissions. A mass emission for Los Angeles only was not performed due to the lack of detailed cigarette sales data. ETS emissions were derived by multiplying the cigarette sales by the per cigarette PM emission rate. As table D-1 indicates, the estimated ETS PM mass emissions declined from 1,290 tons per year to 348 tons per year (73% difference) between 1982 and 2003. This was due to two major factors.

The main reason for such a dramatic reduction was a significant reduction in cigarette sales over time. Statewide cigarette sales data compiled by the California Board of Equalization between 1982 and 2003 indicated that sales had dropped by about 60% (BOE, 2004). Secondly, staff believes that to be more accurate in our estimated PM inventory, it is appropriate to update the parameter used for the per cigarette PM emission rate used for the 1982 estimate. Both the Schauer and Rogge studies use an emission rate (20.4 mg/cigarette) derived by Hildemann for popular brands in 1982. More current studies by Nelson, Martin and Repace result in an emission rate of 13.4 mg/cigarette on average for the popular brands of the 1990's. The Federal Trade Commission has also shown that tar content has declined from 1982 to 2000 (FTC, 2000). Since tar is defined as total PM minus moisture and alkaloids (i.e., nicotine), a reduction in tar means reduction in PM as well. So, we believe it is appropriate to use an updated PM emission rate.

To calculate the 2003 Los Angeles annual average ETS fine particulate concentration, we assumed that: 1) the ratio of fine particulate-emitting sources and fine particulate ambient concentrations from 1982 are comparable to those that exist today, and 2) the decline from 1982 to 2003 in statewide ETS PM emissions (73%) correlates to a linear mass reduction in the outdoor ambient ETS fine PM concentration.

By using the modeled Schauer *et al*., 1996, and the measured Rogge *et al*., 1994, 1982 ETS PM concentrations (0.21 $\mu g/m^3$ and 0.28 – 0.36 $\mu g/m^3$, respectively), and assuming a 73% reduction in ETS PM concentrations, the Los Angeles area annual average ETS fine particulate concentration range is estimated to be 0.06 – 0.10 $\mu g/m^3$ (See Table D-1).

$$\text{2003 ETS PM Concentration } (\mu g/m^3) = C_{1982} \times 0.27;$$

where: C_{1982} = 1982 ETS PM Concentration ($\mu g/m^3$)
0.27 = 1-73% decrease in ETS emissions from 1982 to 2003

In addition, nicotine emission factor studies (Nelson, 1994 and Martin *et al*., 1997) indicated the ratio of ETS derived PM to ETS derived nicotine is about 8:1.

Thus, the range for ETS nicotine concentrations in Los Angeles is estimated to be about

0.008 – 0.013 µg/m^3 (Table D-2). By comparison, the ARB monitoring study showed Los Angeles 8-hour background nicotine levels to be 0.009 to 0.12 µg/m^3. The ARB 8-hour monitoring had an estimated quantitation limit of 0.0036 µg/m^3.

Table D-2

Estimated Range of Ambient ETS PM and Nicotine Concentrations for the Los Angeles Area

Urban Location	Year	ETS Fine PM Concentration (µg/m^3)	ETS Nicotine Concentration (µg/m^3)
Los Angeles Area	2003	0.06 – 0.10	0.008 – 0.013
ARB Monitoring Study Los Angeles Area	2003		* 0.009 – 0.12

* Background as measured from two Los Angeles areas

Conclusion

Since many Californians experience a majority of their personal ETS exposure from a background outdoor ambient level, it is helpful to estimate these levels. The staff used previous Los Angeles area studies, applied an adjustment factor, which included current cigarette sales and emissions data, to estimate an annual average fine PM concentration of 0.06 to 0.10 µg/m^3 in the Los Angeles air.

A more accurate assessment of California ambient ETS levels would require additional research to develop more accurate present day concentration data for use in an updated source apportionment study.

REFERENCES

California State Board of Equalization, (2004). Cigarette Taxes, Tax-Paid Distributions, Research and Statistics Section.
http://www.boe.ca.gov

Federal Trade Commission, (2000). *Tar, Nicotine, and Carbon Monoxide of the Smoke of 1294 Varieties of Domestic Cigarettes for the Year 1998.*

Gray H.A., Cass G.R., Huntzicker J.J., Heyerdahl E.K., Rau, J.A. (1986). *Characterization of Atmospheric Organic and Elemental Carbon Particle Concentrations in Los Angeles*. Sci Total Envir. Vol. 20, pp. 580-589.

Hildemann L.M., Markowski G.R., Cass G.R. (1991). *Chemical Composition of Emissions From Urban Sources of Fine Organic Aerosol*. Envir. Sci. Technol. Vol. 25, pp. 744-759.

Martin P., Heavner D.L, Nelson P.R., Maiolo K.C., Risner C.H., Simmons P.S., Morgan W.T., Ogden M.W. (1997). *Environmental Tobacco Smoke (ETS): A Market Cigarette Study*. Environmental International. Vol. 23, No. 1, pp. 75-90.

Nelson P. (1994). Testimony of R.J. Reynolds Tobacco Company, OSHA Docket No. H-122, *Indoor Air Quality, Proposed Rule*. U.S. Occupational Safety & Health Administration, Washington, D.C.

Rogge W.F., Hildemann L.M., Mazurek M.A., Cass G.R., Simoneit B.R.T. (1994). *Sources of Fine Organic Aerosol: Cigarette Smoke in the Urban Atmosphere*. Enviro. Sci. Technol. Vol. 28, No. 7, pp. 1375-1388.

Schauer J.J., Rogge W.F., Hildemann L.M., Mazurek M.A., Cass G.R., Simoneit B.R.T. (1996). *Source Apportionment of Airborne Particulate Matter Using Organic Compounds as Tracers*. Atmospheric Environment. Vol. 30, No. 22, pp. 3837-3955.